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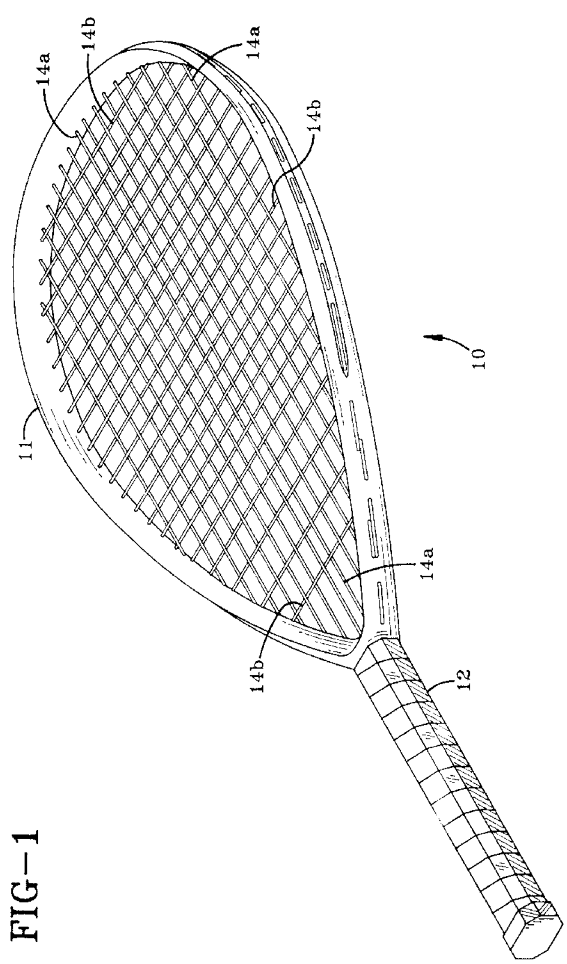
(71) Applicant : **GENCORP INC.**
175 Ghent Road
Fairlawn, Ohio 44333-3300 (US)

(72) Inventor : **Janes, Richard**
11730 North 91st Place
Scottsdale, Arizona 85260 (US)
Inventor : **Douglas, William C.**
4835 E. Cheryl Drive
Scottsdale, Arizona 85253 (US)

(74) Representative : **Stoner, Gerard Patrick et al**
Mewburn Ellis 2 Cursitor Street
London EC4A 1BQ (GB)

(54) **Tennis racquets.**

(57) A tennis racquet comprising a continuously convex bow (11) surrounding a plurality of interlaced tensioned strings (14), and a handle (12) formed integrally with the bow. The racquet is free of a yoke and a shaft and has a sweet spot located relatively close to the distal end of the racquet.



FIG—1

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The invention relates to tennis racquets, and in particular to a tennis racquet frame comprising a convex bow and a handle. More particularly, the invention relates to such a tennis racquet which is free of a yoke and a shaft, and which has a sweet spot located relatively closer to the distal end of the racquet.

Heretofore, a typical tennis racquet structure has included a bow and yoke (collectively referred to as a head), a throat or shaft, and a handle. More specifically, the head has included an elliptical or circular bow containing attached, interlaced strings under tension. The bow conventionally has been attached to a handle through a variety of designs of throats or shafts, ranging from solid shafts to concave splayed, split shafts which typically are tangentially connected to the proximal-outer portions of the bow. The yoke usually has been located near the open proximal portion of the bow to form the lower portion of the head, extending between the inner surfaces of the bow at the transition from the convex bow to the concave shaft of the racquet frame. The yoke inhibits torsional movement of the bow by anchoring the proximal ends of the bow to each other. In addition to preventing torsional movement of the bow when a ball is struck, the yoke also has served to limit the proximal-to-distal string length which in turn inhibits trampolining which might otherwise occur if the yoke were not present and the strings were longer. Moreover, the yoke stabilizes the bow during stringing of the racquet.

However, despite such advantages, the presence of the yoke interrupts the flexion pattern of the bow. Causing the torsional movement of the bow to forceably come to such an abrupt end creates a sharply defined stress riser zone in the racquet at the junction of the bow and shaft. Thus, such shear forces which break up the bending modes as a result of yoke placement, at the least cause unfavorable vibrations to be transmitted to the player's hand, and at worst can cause racquet failure.

Attempts have also been made to improve prior art tennis racquets through continuing advances in metal and composite technologies. These advances have made such materials the choice for most modern tennis racquet frames due to their ability to further improve the stiffness of the frame while reducing the weight thereof, resulting in improved power. However, this increased stiffness has resulted in a significant decrease in the duration of the shock impulse transmitted to the player's hand upon impact of a ball on the racquet strings, which effectively increases the strength of the jolt transmitted to the player's hand, which in turn adversely affects the playability of the racquet. Moreover, the increased height of the bow of many prior art racquets together with the use of such advanced composite materials, also adds to the stiffness of the bow, resulting in further increase in the shock felt by the player upon striking the ball.Thus, the trend in tennis racquet design toward increased stiffness and reduced weight has caused most racquet designers to search for a combination of design elements which maintain power, reduce shock and improve feel, through disposition of the sweet spot of the racquet to a more distal location, or in other words, closer to the general area of ball impact with the strings in most cases. The sweet spot generally is universally defined as being comprised of three separate elements, including, the area of highest coefficient of restitution of the racquet or the area of greatest power, the center of percussion of the racquet or the point at which the racquet will not twist or torque longitudinally or latitudinally, and nodal point or area of the strung face of the racquet where minimal vibration occurs upon ball impact.

However, the advent of racquets having generally larger heads has effectively proximally relocated the sweet spot, or in other words, reduced the distance of the sweet spot to the player's hand. This reduction in distance results in reduced leverage for the player, which especially affects longer and faster strokes such as the service. One hallmark of the larger headed racquets is that the proximal end of the head lies closer to the handle area. It follows that the central portion of the head also is located closer to the handle. As a result, the three elements comprising the sweet spot all are located at or below the latitudinal center of the head, resulting in a loss of leverage for the player. To illustrate this point, a typical wood racquet circa 1960 has a longitudinal head length of 272mm, while a large head racquet circa 1970 has a longitudinal head length of 337mm.

All other dimensions being equal, the center of the large head racquet is more than 30mm closer to the player's hand than the small head wood racquet. Thus, the problem exists of disposing the sweet spot at a more distal location on the head while enjoying the advantages of a large headed racquet, such as greater tolerance on mishit shots.

US-A-4,196,901 (Durbin) is the closest known prior art, and relates to a tennis racquet comprising a frame providing an open, tensioned string receiving, playing head of generally elliptical configuration, and an elongated handle extending from the proximal end of the head along its longer axis and terminating in a hand grip, the configuration of the open head at the proximal end thereof being closed at a point between the center of gravity and the proximal end of said racquet. A preferred form of the racquet comprises a unitary frame bowed in its central portion to form a generally elliptical head configuration and continuing as coplanar throat and shaft extensions which are joined at their extremities in a hand grip, and the first joining of the ends being at a point between the center of gravity and the proximal end of the racquet. Central longitudinal strings may join the frame at points closer to the proximal end than is the center of gravity, and the longitudinal strings are under somewhat greater tension than the transverse strings. The racquet is characterized by reduced weight in the throat portion, resulting in the percussion center of the stringed area being advanced toward the distal end of the racquet, and the vibration level being reduced.

A general problem addressed herein is to provide a new tennis racquet construction.

It is desirable to provide a tennis racquet having a sweet spot located relatively close to the distal end of the head of the racquet.

It is another preferred aim to provide such a tennis racquet having good stiffness, due to a single convex beam or bow of the head of the racquet directly attached to the handle of the racquet.

It is also preferred to provide a tennis racquet having a flex pattern which is pleasant in feel during play, as a result of the bow tapering in width and increasing in height in the proximal-to-distal direction of the racquet.

A further preferred feature is to provide such a tennis racquet having a relatively large head size and strung area with suitable string tension, resulting in increased leverage by moving in a distal direction the area where the player achieves the best feel and power combination, so that accomplished players desiring greater leverage can obtain the same using the tennis racquet.

Still a further preferred feature is to provide such a tennis racquet wherein the distance of the percussion center of the racquet from the player's hand toward the distal end of the racquet is increased, while at the same time reducing overall racquet weight.

Another preferred feature is to provide such a tennis racquet having reduced overall weight due in part to absence of a yoke in the racquet, while retaining the same swing weight values as conventional prior art racquets.

Still another preferred feature is to provide such a tennis racquet having a strung head area of increased longitudinal length, in order to enable strings exhibiting low values of percent elongation to be of desirable elasticity and resilience when used as a tennis racquet string.

A further preferred feature is to provide such a tennis racquet having a relatively long handle which improves the playability of the racquet for two-handed players.

A still further preferred feature is to provide such a tennis racquet having improved power, feel, control, and overall playability.

Another preferred feature is to provide such a tennis racquet which is simple in design, lightweight and economical to manufacture.

Some aspects and preferred features of the invention are set out in the claims.

In one general aspect, the present tennis racquet has a string area enclosed by a bow which is continuously circumferentially convex around the string area and has a root directly meeting the handle of the racquet. Usually, the handle is a single straight element without divergence adjacent the root portion of the bow.

Preferably the cross-section of the bow has a gradual decrease in width (in the string area plane) from the root portion towards the distal end of the bow. It is also preferred that it has a gradual increase in height (perpendicular to the string area plane) in that direction.

Preferably the maximum width of the bow across the string area is nearer to the distal end thereof, e.g. in a teardrop shape.

It is also preferred that the ratio of that maximum bow width to the length of the bow (in the handle direction) be not more than 0.7. The preferred string area is from 110 to 125 square inches.

Embodiments of the invention are now described in detail by way of example, with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of a first tennis racquet;

Fig. 2 is an elevational view of the playing surface of the tennis racquet of Fig. 1, shown without strings or handle grip;

Fig. 3 is an elevational side view of the of Fig. 2;

Fig. 4 is a view similar to Fig. 2, but showing the stringing configuration of the racquet;

Fig. 5 is a sectional view of the bow taken on line 5-5, Fig. 2;

Fig. 5A is a sectional view of the bow taken on line 5A-5A, Fig. 2;

Fig. 5B is a sectional view of the bow taken on line 5B-5B, Fig. 2;

Fig. 5C is a sectional view of the bow taken on line 5C-5C, Fig. 2;

Fig. 5D is a sectional view of the handle taken on line 5D-5D, Fig. 2;

Fig. 5E is a sectional view of the handle taken on line 5E-5E, Fig. 2;

Fig. 5F is a sectional view of the handle taken on line 5F-5F, Fig. 2;

Fig. 5G is a sectional view of the handle taken on line 5G-5G, Fig. 2;

Fig. 6 is an elevational view of the playing surface of a second tennis racquet embodying the invention, shown without strings or handle grip;

Fig. 7 is an elevational side view of the racquet of Fig. 6;

Fig. 8 is a sectional view of the handle taken on line 8-8, Fig. 6;

Fig. 9 is an elevational view of the playing surface of a third tennis racquet embodying the present invention, shown without strings or handle grip; and

Fig. 10 is an elevational side view of the racquet of Fig. 9.

Similar numerals refer to similar parts throughout the drawings.

DETAILED DESCRIPTION

A first embodiment of the tennis racquet of the present invention is indicated generally at 10 and is shown in FIG. 1. Tennis racquet 10 includes a head or bow 11 formed integrally with a handle 12. Racquet 10 can be fabricated from any suitable composite such as a glass fiber reinforced thermosetting plastic, or the like. In general, any material is suitable for fabricating racquet 10 so long as the desired physical characteristics of the racquet described in detail below can be obtained.

Racquet 10 includes a plurality of longitudinally and transversely extending strings 14a and 14b, respectively, contained within and securely attached to bow 11 in the manner shown in Fig. 4. Longitudinally extending strings 14a preferably have an elongation value of less than about 5 percent at 60 lbs. pull tension. Transversely extending strings 14b preferably have an elongation value of less than about 8 to about 12 percent at 60 lbs. pull tension. Suitable materials for longitudinally extending strings 14a include polyester and aramid (e.g. Kevlar®), with aramid being preferred. Suitable materials for transversely extending strings 14b include Nylon 66 and natural animal gut, with Nylon 66 being preferred. The pull tension of all strings of the racquet preferably is from about 50 to about 60lbs. It has been found that the above parameters minimize trampolining of the strings. Trampolining is the result of too much extension in the strings caused either by strings that are too long or by too little tension in the strings, which in turn results in loss of control of ball speed and direction.

It is an important feature of the racquet that the bow 11 is entirely convex and continuous and is formed integrally with handle 12. This structure differs from known conventional tennis racquets, which include a yoke forming the proximal portion of the head adjacent to a concave throat or shaft which connects the handle to the bow of the head. As shown in Figs. 3, 5, 5A, 5B and 5C, the cross-sectional configuration around bow 11 is varied to support the varying forces to which the racquet is subjected during play. More particularly, in moving from the proximal end of bow 11 at Fig. 5B to the distal end of the bow at Fig. 5, the width of the bow (in the string plane) clearly tapers and the height (perpendicular to the string plane) increases. The absence of a yoke saves 50 to 60g (2 ounces) in weight without affecting the overall stiffness of racquet 10 due to the variable cross section of bow 11. Moreover, weight saved by the absence of a yoke can be redistributed to the bow 11 in various areas to improve longitudinal or transverse inertia for increasing stability in light of the lessened weight. In addition, absence of a yoke allows the bending mode or moment of the bow 11 to occur naturally during play whereby the tennis player experiences a pleasant feel with low vibration to the hand during impact of the strung racquet face with a tennis ball.

In contrast, the yoke of known prior art tennis racquets, as well as the throat or shaft, generally stops the rotation of the bow resulting in a shear point which decreases durability as well as creating an interruption in the bending mode, which imparts an unpleasant feel or vibration to the hand of the player during ball impact. Since the tennis racquet as described here does not utilize a convex bow connected to the handle through a transitional concave shaft, weakness at the convex-concave transition is avoided. Thus, a yoke is unnecessary to control the tremendous twisting which occurs due to such a convex-concave structure.

Again, the present racquet is found to have good durability and playability without the yoke, owing to the convex-only design of bow 11 coupled with the variable cross section of the bow. Exclusive use of a convex bow 11 in racquet 10 without a concave shaft results in a more even flow of flex or longer bending moment during and after impact with a ball, since the arc of the bow is unchanged and the bow will flex or rotate only in a single direction. Known prior art tennis racquets incorporating the conventional convex-concave design typically have the convex bow rotating in one direction and the concave shaft rotating in an opposite direction upon and after impacting a ball, thereby creating a shear point which has been observed in laboratory and field tests as well as via finite element analysis. In contrast, the convex-only variable cross-section bow 11 of the racquet 10 described herein results in a stronger supportive bow 11 which rotates only slightly in a single direction during and after impacting a ball for good feel, and in particular results in a bow exhibiting good strength characteristics in its distal portions. Such strength is necessary to resist the strong inwardly-directed forces associated with the string tensions acting upon bow 11 of racquet 10, which can approach 2.000 lbs (910kgf).

Another important feature of this racquet is that the bow 11 is relatively long combined with a normal width, as illustrated especially in Fig. 2. More particularly, the length of bow 11 of the first embodiment of racquet 10 is 422 mm (16.6 inches) as indicated by distance c in Fig. 2, and its width is 259mm (10.19 inches) as indicated by distance e in Fig. 2, resulting in a head size strung area of about 0.11m^2 (121 square inches). The ratio of the width of bow 11 to the length of the bow in the racquet is 0.62, or distances d to b as shown in Fig. 2, is 0.62, while those of conventional prior art tennis racquets are generally 0.75 to 0.76. It should be noted that distance f in Fig. 3 has a value of 295 mm.

Handle 12 generally is conventional in shape as shown in Figs. 1-3 and 5D-5G. However, due to the unique design of racquet 10 of the invention, whereby the racquet lacks a shaft and yoke, handle 12 can be made longer, which results in improved playability of the racquet for two-handed players. As shown in Fig. 2, the length of handle 12 is represented as distance a or 257mm.

We find that in the present construction the sweet spot of tennis racquet is located relatively close to the distal end of bow 11 on strings 14. In actuality, the general sweet spot is comprised of three discrete elements, as previously described herein. As also discussed hereinabove, movement of the sweet spot relatively closer to the distal end of the racquet improves leverage for the tennis player. More particularly, leverage is directly proportional to the distance from the proximal end of handle 12 to the sweet spot. The greater this distance, the greater leverage experienced by the tennis player.

More specifically the first discrete element which contributes to the overall sweet spot is the nodal point (not shown), which is the area of strings 14 where minimal vibration occurs during ball impact.

The second discrete sweet spot element is the point of highest coefficient of restitution (not shown) or area of greatest power on the strung surface of racquet 10. The point of coefficient of restitution (hereinafter COR) is the area where the greatest support of bow 11 occurs and is usually towards the proximal end of bow 11. In general, the closer the COR is to the proximal end of bow 11, the weaker the COR will be in the distal nodal areas of the bow, which in turn results in weakness in the distal areas of the bow of racquet 10. Bow 11 of the present racquet 10 has a good COR in the distal area of bow 11 by supporting the distal bow area as strongly as possible through elimination of the convex-concave bends found in prior art tennis racquet frames. That is, by directly connecting convex bow 11 to handle 12, the distal bow support is strengthened and resistance to twist due to off-center hits is greatly increased which results in greater power or COR in the distal bow area.

The third discrete sweet spot element is the point of center of percussion (not shown and hereafter referred to as CP), which is the point at which racquet 10 will not twist or torque longitudinally or transversely. It is understood that CP can be easily moved by adjusting the location of mass in the racquet frame. For example, absence of weight from the area of center of gravity of the racquet by absence of the yoke and distribution of the mass thereof around bow 11, as has been accomplished in the racquet 10 described here, causes the CP to move toward the distal end of the racquet. This results in improved strength in racquet 10, thus lowering the likelihood that the handle will be apt to twist or jump out of a player's hand upon impact with a ball. Stated another way, as CP approaches the distal end of the racquet, racquet rotation on impact is decreased resulting in a more pleasant feel. Thus, although the CP heretofore has generally resided in the proximal head area of a racquet, it can be moved distally by a relative shift of racquet mass from the central area of the racquet to the distal end of the bow, e.g. by absence of the yoke and increase in the mass of bow 11 of racquet 10 described here.

As shown in Figs. 3 through 5C, another manner in which power is added to the distal area of bow 11 of racquet 10 is to increase the height of the bow in the distal bow area. Increasing the height in moving from the proximal bow area to the distal bow area reduces vibration and shock enabling bow 11 to gradually flex more as it approaches the handle area. In addition, the width of bow 11 tapers from wider in the proximal area of the bow to thinner in the distal area. Thus, the use of a wider but lower bow in the proximal end of bow 11 which tapers to a thinner but higher bow in the distal end controls the flex pattern and increases resistance to torque. Such controlled flex gives a solid feel to the tennis racquet without the sudden jolt of an off-center ball impact. This controlled perimeter three-dimensional taper design is extremely desirable due to the increased lay-up accuracy associated with a constant perimeter geometry.

The power zone of the racquet 10 substantially covers the entire strung surface of the racquet, and is moved relatively closer to the distal end of the racquet due to the absence of a yoke and redistribution of yoke mass in bow 11, and further due to the single convex tapered configuration of the bow. A power zone is defined as the strung area which shows a coefficient of restitution greater than 0.35.

A second embodiment of tennis racquet is indicated generally as 20 and is shown in Figs. 6-8. Tennis racquet 20 includes a head or bow 21 formed integrally with a handle 22. Racquet 20 is similar to racquet 10 in most respects, except that the inside and outside widths of bow 21 of racquet 20 are less than those of bow 11 of racquet 10. Specifically, the inside and outside widths of bow 21 are represented by e' and d' in Fig. 6, respectively, and have values of 243.16mm and 267.78 mm. Moreover, handle 22 differs from handle 12 of racquet 10 in its cross-sectional design as shown in Fig. 8. Handle 22 is lighter than most conventional tennis racquet handles, yet still exhibits suitable shock absorbing and indexing properties. This lightweight feature of handle 22 serves to move the percussion center of racquet 20 even further distally. Handle 22 is more fully described in our European Patent Application claiming the priority of USSN 815109 and filed on the same day as this application, which is hereby fully incorporated by reference herein.

A third embodiment of the present invention is indicated generally at 30 and is shown in Figs. 9 and 10. Racquet 30 includes a bow 31 formed integrally with a handle 32, and is similar to racquet 10 in most respects except that the inside and outside widths of bow 31 of racquet 30 are slightly less than those of bow 11 of racquet 10. Specifically, the inside and outside widths of bow 31 are represented by e" and d" in Fig. 9, respectively, and have values of 254.23mm and 278.23mm.

In summary, we have described how to make a racquet with a sweet spot located relatively closer to the distal end of the head of the racquet due to the absence of a yoke and a shaft from the racquet design. This distal movement of the sweet spot results in greater leverage for the tennis player than would be possible using other racquets having similar head sizes. The design features accomplishing distal movement of the sweet spot result in a tennis racquet having improved power, feel, control and overall playability. The absence of a yoke allows the bending moment of the bow to occur naturally during play, whereby the tennis player experiences a pleasant feel with low vibration to the hand during impact of the strung racquet face with a tennis ball. The improved durability and playability of the racquet despite the absence of a yoke is attributable to the convex-only design of the bow coupled with the variable cross-section of the bow. Absence of a concave shaft results in a more even flow of flex or a longer bending moment during and after impact with a ball.

Claims

1. A tennis racquet comprising:

   a continuous convex bow containing a plurality of interlaced strings attached under tension to said bow; and

   a handle integrally attached to said bow, said racquet being free of a yoke and a shaft.

2. The racquet of Claim 1, wherein the bow is generally teardrop-shaped; and wherein said bow generally tapers in width and increases in height in moving from the proximal to the distal end of said bow.

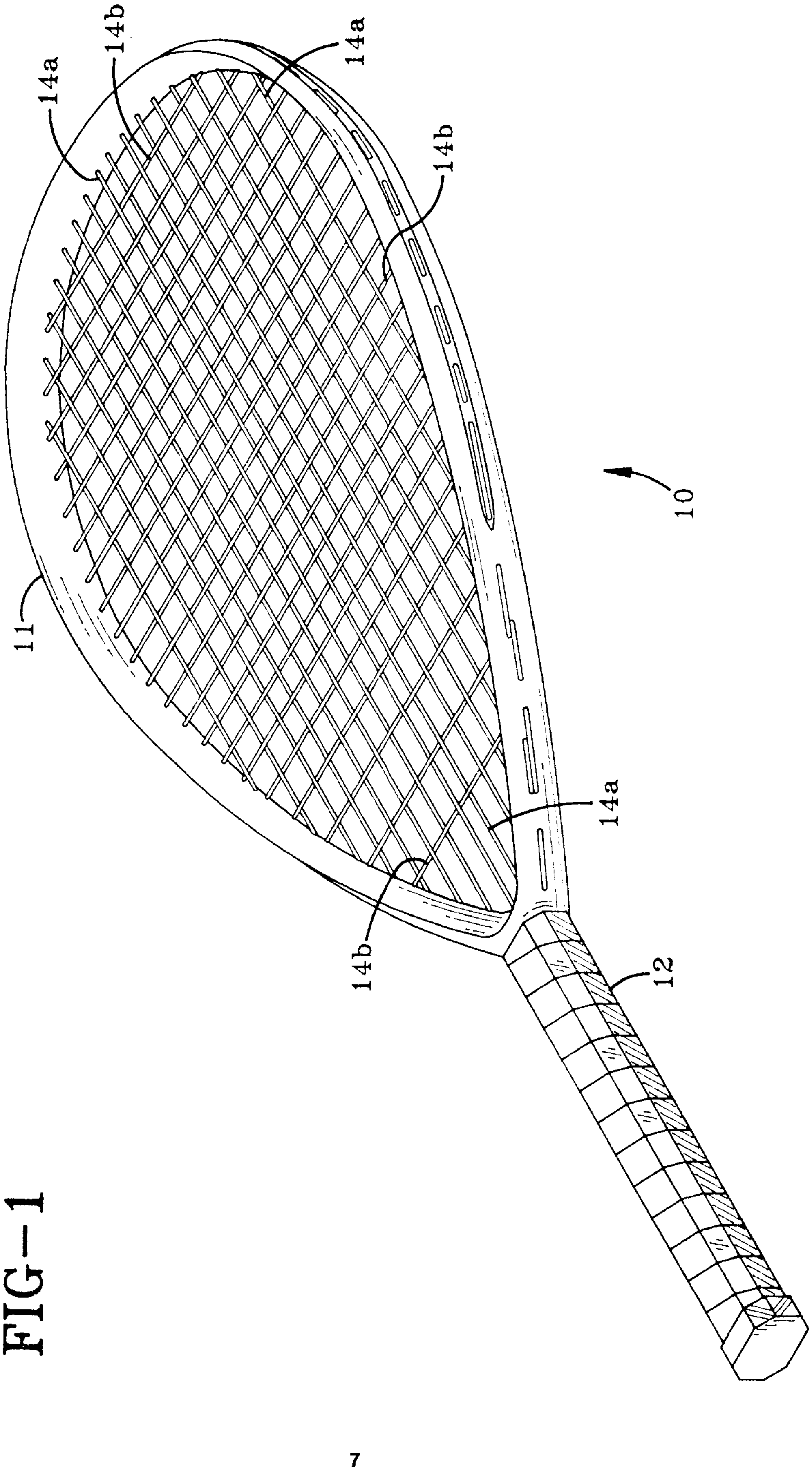
3. The racquet of Claim 2, wherein the ratio of the width to the length of said bow as measured at its widest and longest points is about 0.62; and wherein the area of strung surface of said racquet is about 121 square inches.

4. The racquet of Claim 2, wherein the ratio of the width to the length of said bow as measured at its widest and longest points is about 0.59; and wherein the area of strung surface of said racquet is about 113 square inches.

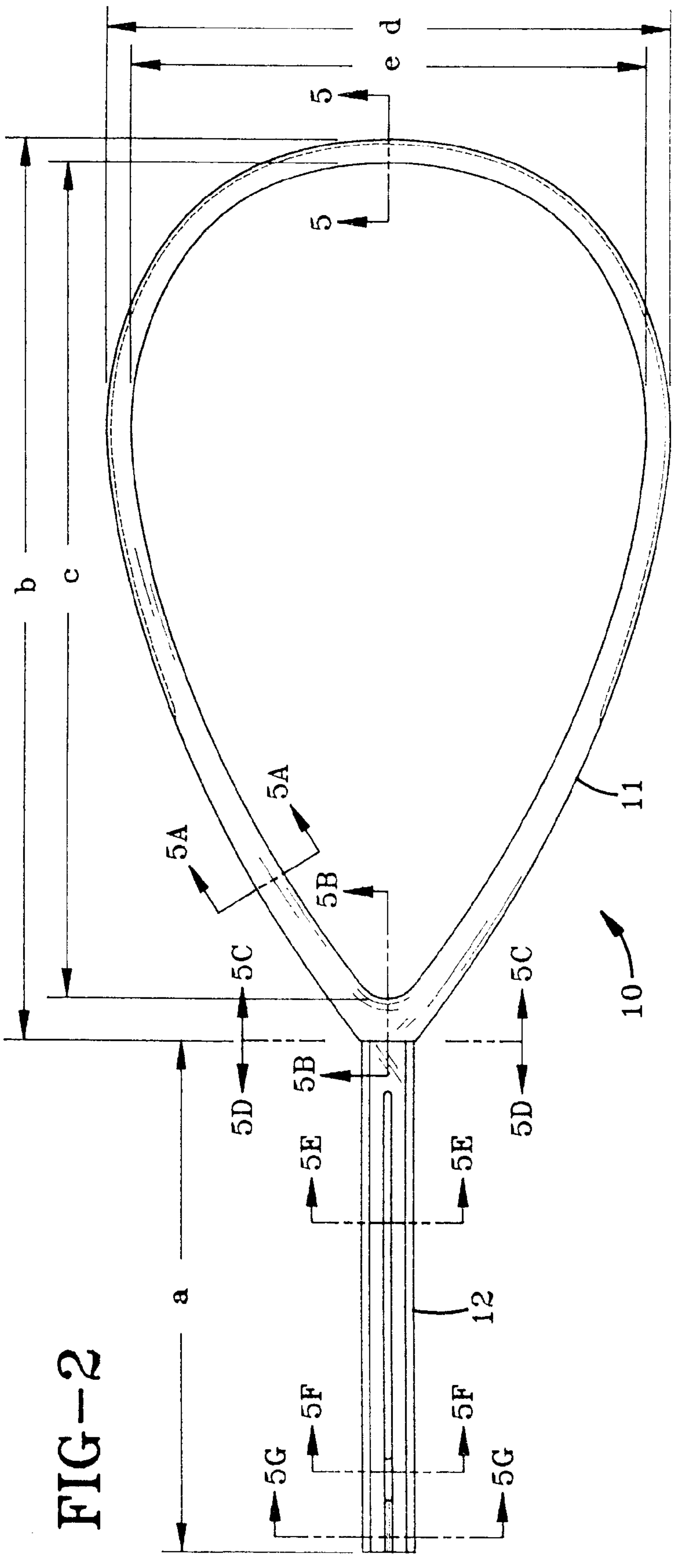
5. The racquet of Claim 2, wherein the ratio of the width to the length of said bow as measured at its widest and longest points is about 0.61; and wherein the area of strung surface of said racquet is about 118 square inches.

6. The racquet of Claim 3, wherein said bow is formed of a composite material.

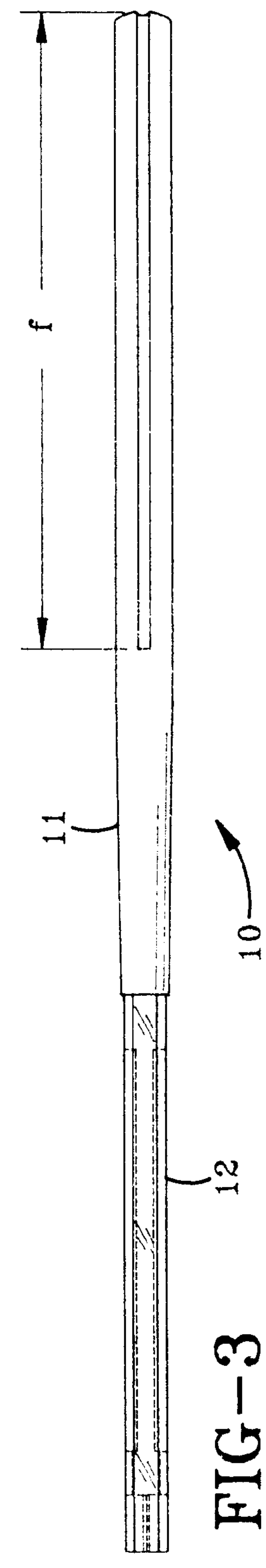
7. The racquet of Claim 6, wherein said interlaced strings include longitudinally and transversely extending strings; and wherein said longitudinally extending strings are formed of an aromatic polyamide fiber and have an elongation value of less than about 5 percent at 60 lbs. pull tension, and said transversely extending strings are formed of Nylon 66 and have an elongation value of less than about 8 percent to about 12 percent at 60 lbs. pull tension.



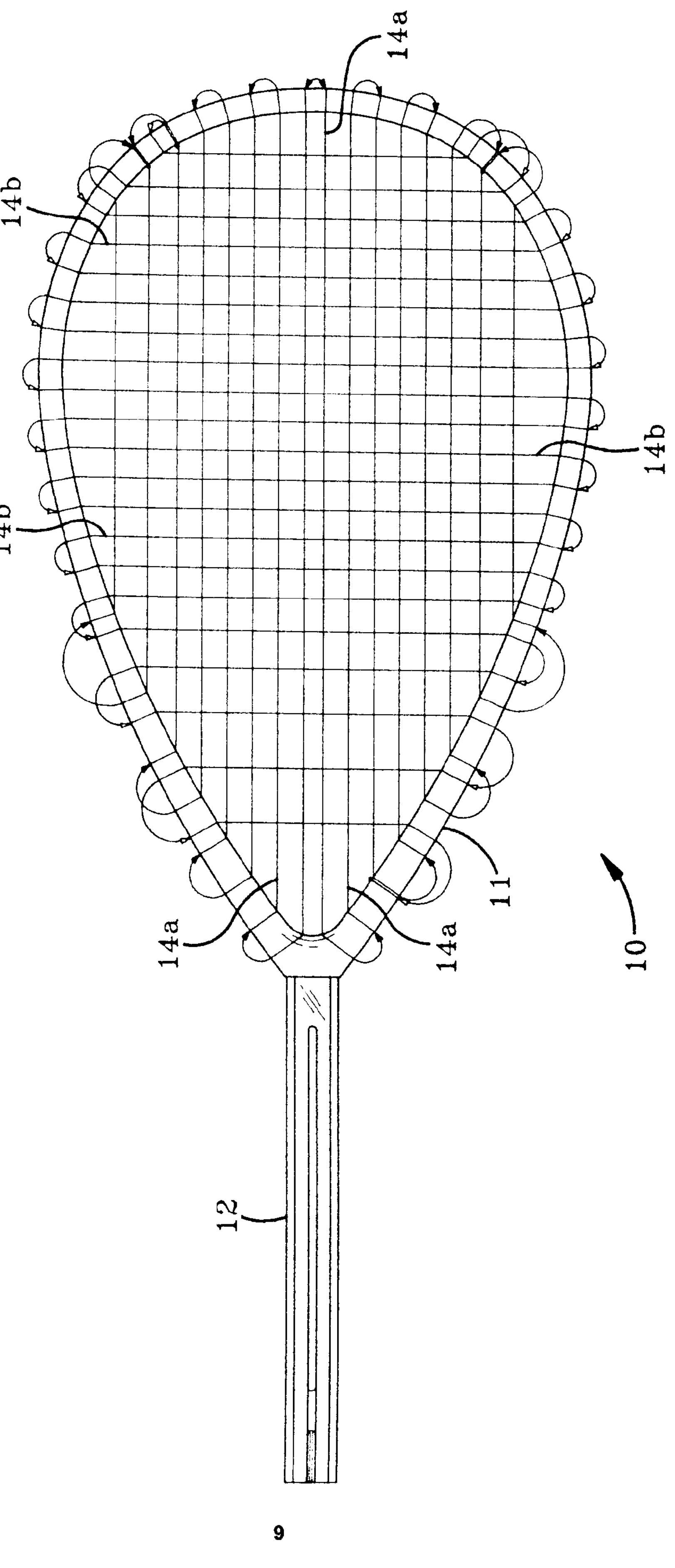
FIG—1



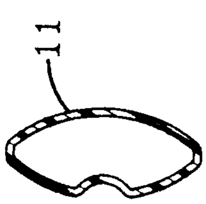
FIG–2



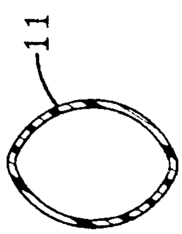
FIG–3



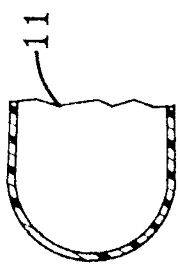
FIG—4



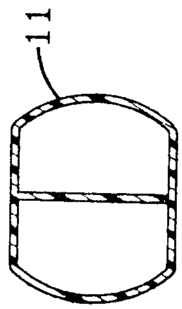
FIG—5



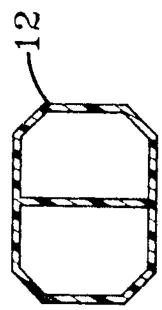
FIG—5A



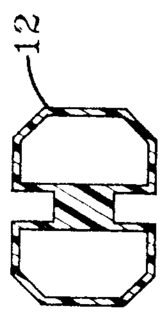
FIG—5B



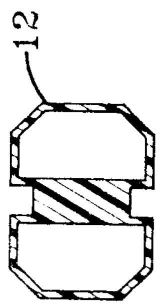
FIG—5C



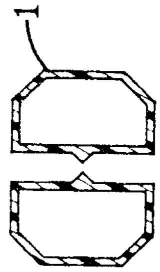
FIG—5D



FIG—5E



FIG—5F



FIG—5G

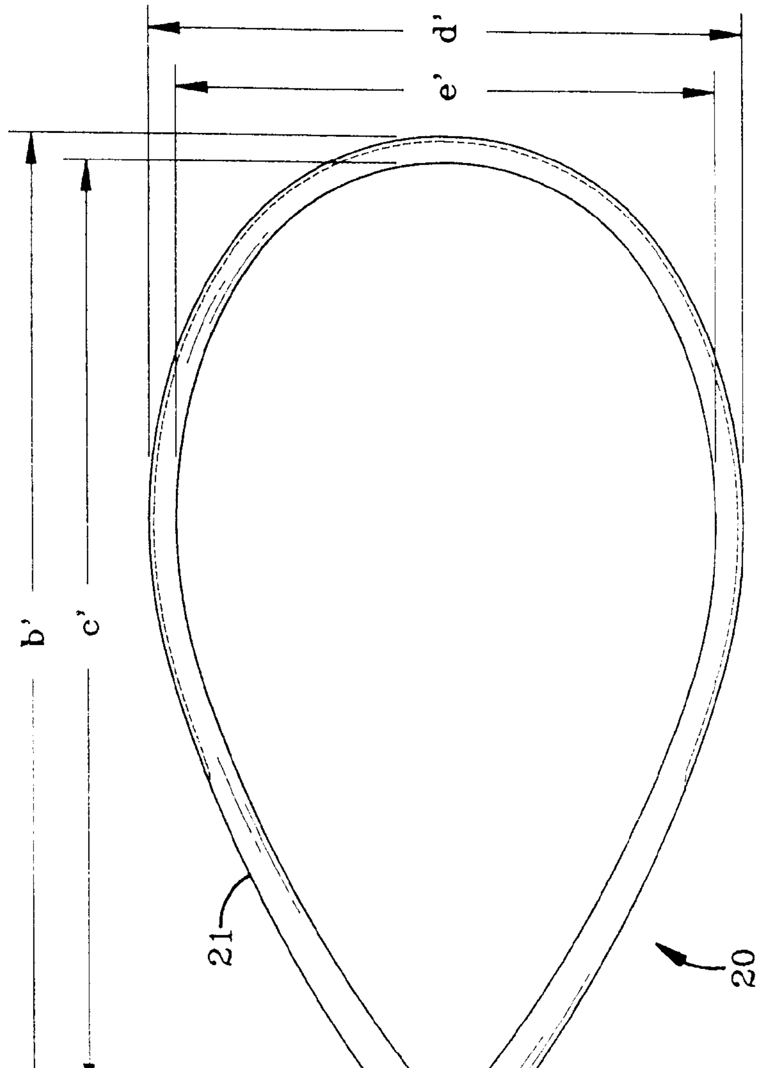
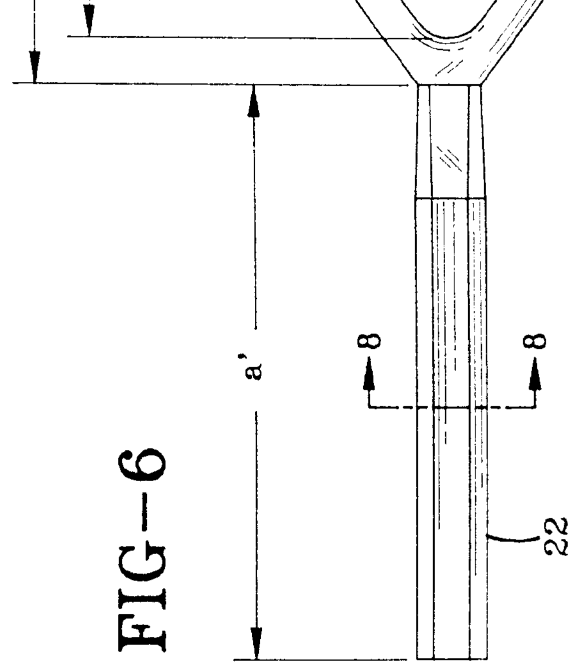



FIG-6

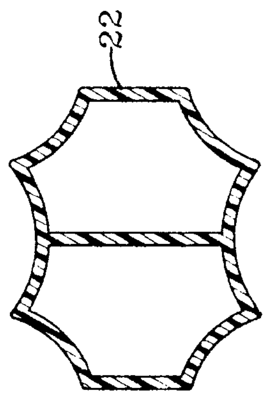


FIG-8

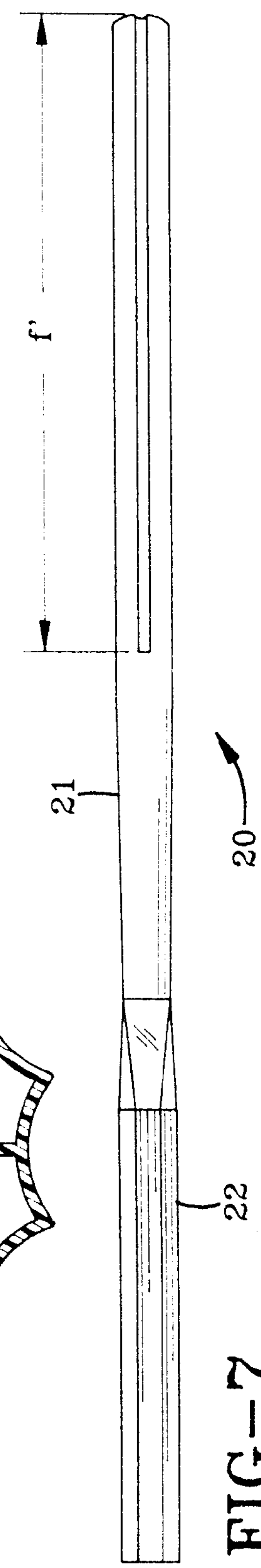
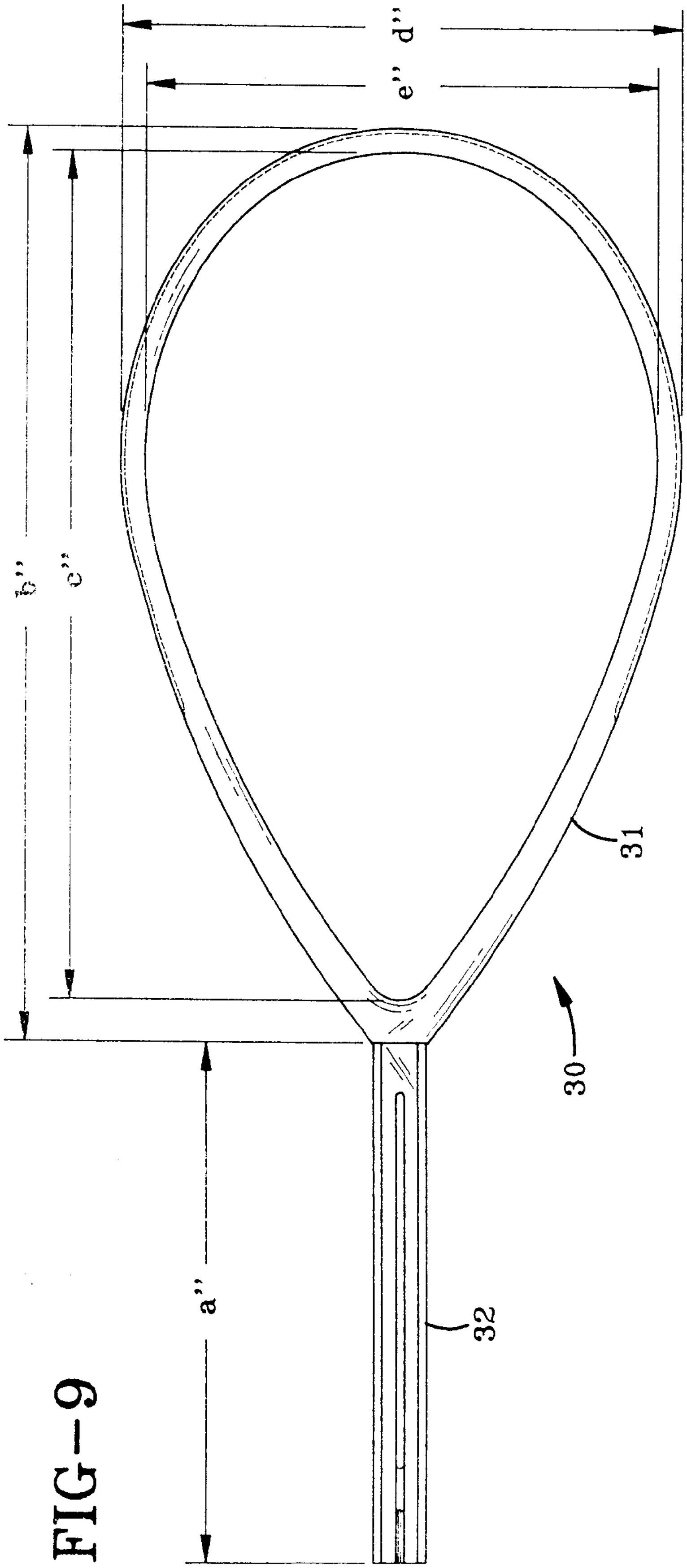
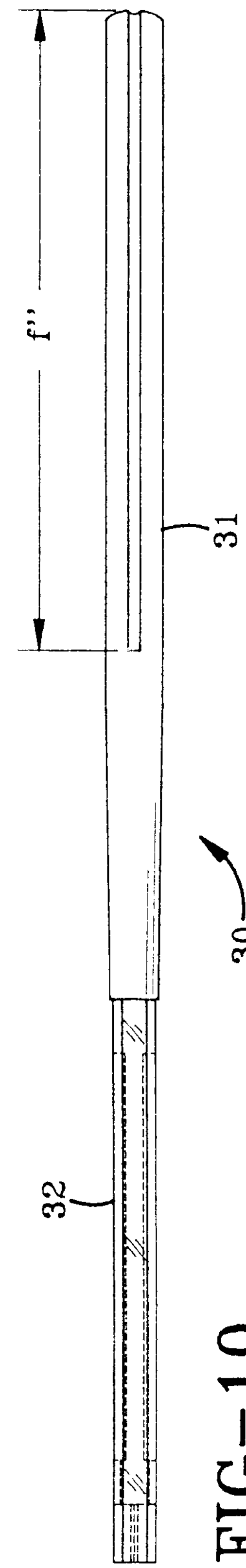


FIG-7



FIG−9



FIG−10

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 92 31 1737

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	DE-A-2 045 499 (H KÖNIG) * the whole document * ---	1	A63B49/02
P,X	DE-U-9 205 164 (T KUNI) * figure 2 * ---	1	
X	LU-A-34 739 (O FUCHS) * the whole document * ---	1	
A	WO-A-8 002 510 (J FROLOW) * the whole document * ---	1-3	
A	DE-A-2 546 028 (PRINCE MFG INC) * the whole document * ---	1,3-5	
A	GB-A-2 028 144 (D EPSTEIN) * page 1, line 33 - line 54 * * page 2, line 30 - line 38 * * figures * ---	1,3-5	
A	GB-A-2 070 445 (AMF INC) * the whole document * ---	1,2-6	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	BE-A-827 888 (M VERZELE) * the whole document * ---	1,2-5	A63B
A	DE-U-8 617 719 (W POTUTSCHNIG) * the whole document * -----	1,2-5	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	05 APRIL 1993	VEREECKE A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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